

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL HARDWARE

NUMBER: M7-3-M1-X

5050270A
ATTACHMENT -
PAGE 96 OF 140

SUBSYSTEM NAME: TUNNEL ADAPTER

REVISION : 1 05/17/91

| | PART NAME VENDOR NAME | PART NUMBER VENDOR NUMBER |
|---------|----------------------------|------------------------------|
| ■ LRU : | LATCH MECHANISM, HATCH "C" | M072-593302 |

 PART DATA

■ EXTENDED DESCRIPTION OF PART UNDER ANALYSIS:
LATCH MECHANISM, HATCH "C"

■ QUANTITY OF LIKE ITEMS: 1
ONE

■ FUNCTION:
THIS MECHANISM IS MOUNTED ON OUTER (LOW PRESSURE) SIDE OF HATCH "C" (A MISSION MODIFIED HATCH "B") TO SECURE IT IN A CLOSED AND SEALED POSITION. THIS MECHANISM CONSISTS OF SIX (6) APOLLO CREW MODULE-TYPE LATCHES JOINED BY RODS AND LINKS THAT MOVE CIRCUMFERENTIALLY, DRIVEN BY A MANUALLY OPERATED REDUCTION GEARBOX (ACTUATOR). TWO "KICKER" LATCHES ON HATCH "C" INCORPORATE PROVISION FOR "BREAKING" THE HATCH SEALS AGAINST ANY SMALL RESIDUAL DELTA PRESSURE, WHEN OPENING THE HATCH.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M7-3-M1-02

S050270A
ATTACHMENT -
PAGE 101 OF 11

REVISION# 1 05/17/91 R

SUBSYSTEM: TUNNEL ADAPTER
LRU :LATCH MECHANISM, HATCH "C"
ITEM NAME: LATCH MECHANISM, HATCH "C"

CRITICALITY OF THIS
FAILURE MODE:1/1

■ FAILURE MODE:
FAILS TO ENGAGE

MISSION PHASE:
00 ON-ORBIT

■ VEHICLE/PAYLOAD/KIT EFFECTIVITY: 102 COLUMBIA
: 103 DISCOVERY
: 104 ATLANTIS
: 105 ENDEAVOUR

■ CAUSE:
ADVERSE TOLERANCES/WEAR, CONTAMINATION/FOREIGN OBJECT/DEBRIS, FAILURE/
DEFLECTION OF INTERNAL PART, PHYSICAL BINDING/JAMMING

■ CRITICALITY 1/1 DURING INTACT ABORT ONLY? NO

■ REDUNDANCY SCREEN A) N/A
■ B) N/A
■ C) N/A

PASS/FAIL RATIONALE:

■ A)
N/A

■ B)
N/A

■ C)
N/A

- FAILURE EFFECTS -

■ (A) SUBSYSTEM:
LATCHES THAT FAIL TO ENGAGE WILL CAUSE THE LOSS OF THE ABILITY TO
(MECHANICALLY) KEEP THE HATCH CLOSED AND SEALED. A CREWMEMBER RETURNING
FROM EVA CAN ATTEMPT TO REPRESSURIZE THE AIRLOCK/TUNNEL ADAPTER ONLY

**FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M7-3-M1-02**

SD50270A
ATTACHMENT -
PAGE 102 OF 140

AFTER HOLDING HATCH "C" AND THE PRESSURE ASSISTED SEALS IN PLACE DURING THE PRESSURE BUILDUP UNTIL IT IS SAFE TO RE-ENTER THE CREW MODULE.

- **(B) INTERFACING SUBSYSTEM(S):**
DEGRADED CAPABILITY TO RE-PRESSURIZE THE AIRLOCK (POST-EVA), IF A FLIGHT CREWMEMBER HAS TO FIRST PUSH ON HATCH "C" TO MAKE THE INITIAL SEAL DURING THE PRESSURE BUILDUP.
- **(C) MISSION:**
IT WOULD BE UNSAFE TO USE THE AIRLOCK/TUNNEL ADAPTER AS A PASSAGEWAY BETWEEN THE CREW MODULE AND THE SPACE LAB IF HATCH "C" CANNOT BE LATCHED CLOSED POST-EVA TO PREVENT ITS INADVERTENT OPENING AND THE SUBSEQUENT LOSS OF AIR PRESSURE. POSSIBLE LOSS OF OR DEGRADATION OF SOME MISSION OBJECTIVES.
- **(D) CREW, VEHICLE, AND ELEMENT(S):**
POSSIBLE INJURY TO OR LOSS OF EVA CREWMEMBERS IF HATCH "C" CANNOT BE KEPT CLOSED AND SEALED TO ALLOW THEIR SAFE RETURN INTO THE CREW CABIN POST-EVA.
- **(E) FUNCTIONAL CRITICALITY EFFECTS:**

- DISPOSITION RATIONALE -

- **(A) DESIGN:**
LATCH MECHANISM BASED ON PROVEN APOLLO DESIGN. LINKAGE ATTACHMENTS HAVE DUAL ROTATING SURFACES, POSITIVE MARGINS ON ALL COMPONENTS. PROTECTIVE COVER MINIMIZES CONTAMINATION. MAXIMUM LATCHING FORCE IS 30 LB AT THE ACTUATOR HANDLE. ACTUATOR AND LINKAGE DESIGNED FOR 150 LB LIMIT LOAD AT THE HANDLE. LATCH AND LINKAGE MATERIALS (INCONEL, A286 CRES, BERYLLIUM COPPER) CHOSEN FOR HIGH STRENGTH AND LOW WEAR. DRY FILM LUBE ON BEARING SURFACES. DIFFERENTIAL PRESSURE IN HATCH CLOSING DIRECTION. DESIGN STRESS ANALYSIS REPORT SD77-SH-0178, VOL. 6.
- **(B) TEST:**
QUALIFICATION TESTS: LATCHES AND ACTUATOR SYSTEM QUALIFIED BY SIMILARITY (PER CR-28-593201-001C) TO THE MECHANISMS ON THE INGRESS/EGRESS HATCH. REFERENCE FMEA/CIL 02-4A-593201-01. ACTUATOR ALSO COMPONENT QUALIFIED BY SIMILARITY TO ACTUATOR ON INGRESS/EGRESS HATCH (PER CR-28-287-0036-0006C); REFERENCE FMEA/CIL 02-4A-593202-01. CERTIFICATION BY SIMILARITY INCLUDED: FUNGUS, SALT/FOG, OZONE, SAND/DUST, TEMPERATURE CYCLE, CRASH/SHOCK, ACCELERATION, CABIN ATMOSPHERE, LIFE CYCLE (2,000 CYCLES), VIBRATION AND STRUCTURAL LOAD REQUIREMENTS.

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M7-3-M1-02S050270A
ATTACHMENT -
PAGE 103 OF 140

CERTIFICATION TESTS INCLUDED: ZERO-"G" AND ONE-"G" OPERATION (USING APPROPRIATE GSE EQUIPMENT) AND HATCH SEALING/LEAK TEST (WITH 15.0 PSID ACROSS HIGH-PRESSURE SIDE OF HATCH, WITH MAXIMUM ALLOWABLE LEAK RATE OF 1.03 SCIM), PROOF PRESSURE 17.7 PSID FOR 2.0 +/- 1.0 MINUTE (PER MLO2D6-0089). LATCH MECHANISM INSTALLED AND RIGGED PER TECH ORDER INSTALLATION M072-593301.

OMRSD: MECHANISM IS FUNCTIONALLY OPERATED FOR EVIDENCE OF BINDING, SURFACE CONTAMINATION AND POSSIBLE DAMAGE. VISUALLY INSPECT TUNNEL ADAPTER HATCH "C" MECHANISM LATCHES AND HINGES. FUNCTIONAL CHECK OF HATCH "C" IS PERFORMED BY OPENING AND CLOSING HATCH FROM INSIDE TUNNEL ADAPTER AND REPEATING FROM OUTSIDE ADAPTER. ACTUATOR HANDLE AND LOCK LEVER FORCES ARE CHECKED. TESTS ARE PERFORMED WHEN THE TUNNEL ADAPTER IS INSTALLED ON THE VEHICLE.

REFERENCE OMRSD V33A00.OXX.

- (C) INSPECTION:
RECEIVING INSPECTION
MATERIAL AND PROCESS CERTIFICATIONS VERIFIED BY INSPECTION.

CONTAMINATION CONTROL
CORROSION PROTECTION PROCESSES ARE VERIFIED BY INSPECTION.

ASSEMBLY/INSTALLATION
ALL DETAIL HARDWARE IS VERIFIED BY INSPECTION AT THE DETAIL LEVEL. INSPECTION VERIFICATION IS REVERIFIED PRIOR TO ASSEMBLY. ALL LATCHES ARE INSTALLED AND SYSTEMATICALLY TORQUED AND VERIFIED BY INSPECTION. ALL FASTENER TORQUES ARE VERIFIED BY INSPECTION. PEAK TORQUE (35 INCH-LB) AT EACH LATCH BELLCRANK IS MEASURED DURING INSTALLATION AND VERIFIED BY INSPECTION. ALL INSTALLATIONS, ADJUSTMENTS, AND RIGGING OF MECHANICAL UNITS (PER MLO308-0003) ARE VERIFIED BY INSPECTION.

NONDESTRUCTIVE EVALUATION
PENETRANT INSPECTION OF DETAIL HARDWARE IS VERIFIED BY INSPECTION.

CRITICAL PROCESSES
DRY FILM LUBRICATION VERIFIED BY INSPECTION.

TESTING
FUNCTIONAL TESTING VERIFIED BY INSPECTION.

- (D) FAILURE HISTORY:
CAR NO. AB3854: DURING VISUAL INSPECTION OF SIDE HATCH ASSEMBLY AFTER COMPLETION OF LIFE CYCLE TESTS AND QUALIFICATION VIBRATION TEST, TWO SHIMS WERE FOUND TORN AND WRINKLED IN LATCHES NO. 6 AND NO. 7; SHIM

FAILURE MODES EFFECTS ANALYSIS (FMEA) -- CRITICAL FAILURE MODE
NUMBER: M7-3-M1-02

S050270A
ATTACHMENT -
PAGE 104 OF 140

DAMAGE RESULTED FROM RADIAL (INWARD) LOADING ON LATCH BELLCRANKS DURING MORE THAN 2,000 CYCLES OF OPENING AND CLOSING THE HATCH; ALL SHIMS ON THE QUALIFICATION TEST HATCH WERE RE-INSPECTED AND REPLACED, BUT NO CORRECTIVE ACTION WAS REQUIRED AS HATCH LATCHING MECHANISM PERFORMANCE WAS NOT AFFECTED.

CAR NO. AB7348: THERE WERE UNSUCCESSFUL ATTEMPTS TO MOVE HATCH "A" TO THE CLOSED POSITION; INABILITY TO CLOSE HATCH WAS A RESULT OF MISALIGNMENT BETWEEN HINGE STOP ASSEMBLY AND LOWER HINGE ARM DUE TO YIELDING (WHICH WAS ATTRIBUTED TO IMPROPER OPERATION OF THE HATCH HINGE MECHANISM AND APPLICATION OF EXCESSIVE FORCE TO THE GSE COUNTER-BALANCE); YIELDED PARTS FROM AIRLOCK HATCH "A" WERE REPLACED AND THE AIRLOCK MECHANISM TECH ORDER INSTALLATION WAS CHANGED TO CLARIFY OPERATION OF HATCHES "A" AND "B" DURING GROUND CHECKOUT.

CAR NO. AB7674 : IN GROUND CHECKOUT OF AIRLOCK HATCH "B" ON OV102, CLOSING OPERATION WAS UNSUCCESSFUL IN FOUR ATTEMPTS; THE KICKER DOG ON THE CENTER LATCH WAS ON THE WRONG SIDE OF THE HATCH SILL WHICH PREVENTED ACTUATION OF LATCHES TO THE LATCHED POSITION (LATCH MECHANISM KINEMATICS ALLOWED THE CENTER LATCH KICKER DOG TO INTERFERE WITH HATCH CLOSING BECAUSE OF HATCH ORIENTATION WITH GSE SUPPORT IN ONE-G ENVIRONMENT); A DECAL WAS ATTACHED TO EACH SIDE OF AIRLOCK HATCHES "A" AND "B" TO INDICATE THE REQUIRED POSITION OF THE LATCH ACTUATOR HANDLE FOR CLOSING THE HATCH.

CAR NO. 26F009: AIRLOCK HATCH "A" DIFFICULT TO LATCH FOR ENTRY; YIELDING OF HINGE MECHANISM PARTS DUE TO OPENING HATCH AFTER SPACELAB FLIGHTS WITHOUT GSE SUPPORT; YIELDED PARTS REPLACED AND HATCH OPERATION REVERIFIED TO INCORPORATE RE-INSPECTION OF HATCH MECHANISMS AFTER EMERGENCY OPERATION WITHOUT GSE.

■ (E) OPERATIONAL USE:

EVA CREWMEMBER CAN MANUALLY HOLD TUNNEL ADAPTER HATCH "C" IN THE CLOSED POSITION DURING REPRESSURIZATION OF THE AIRLOCK UNTIL THE PRESSURE DIFFERENTIAL (OF 3.2 PSI MINIMUM) IS SUFFICIENT TO HOLD AND SEAL THE HATCH IN POSITION AND THEN ALLOW FOR RE-ENTRY INTO THE CABIN THROUGH AIRLOCK HATCH "A".

- APPROVALS -

RELIABILITY ENGINEERING: D. M. MAYNE
DESIGN ENGINEERING : R. A. SMITH
QUALITY ENGINEERING : M. SAVALA
NASA RELIABILITY :
NASA SUBSYSTEM MANAGER :
NASA QUALITY ASSURANCE :

D.M. Mayne
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